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TESTS OF SANDWICH PLANTING AND THE MECHANICAL PLANTING HOLE DIGGER IN CALIFORNIA

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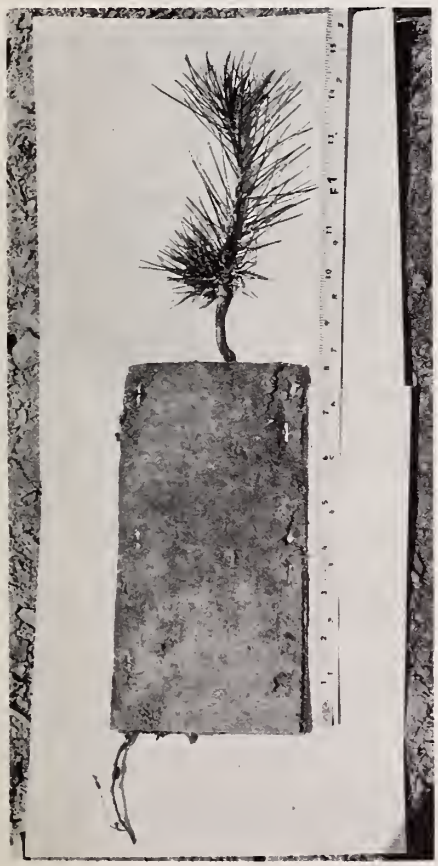

Two new planting techniques were tested in California in 1958. These trials were part of a continuing program carried on by foresters who are looking for ways to plant conifers more efficiently and insure high seedling survival during the first long, dry summer.

The first innovation was planting in "sandwiches" (fig. 1). This method consists of encasing the seedling's roots between two pieces of a stiff, water-absorbent, fibrous material (about 3 x 8 inches) which are stapled together.

Sandwich planting was conceived by Roland Rotty of the Washington Office, U.S. Forest Service. He believed the stiffness of the sandwiches would force planters to set the seedlings in the ground properly, because the roots could not be bent up in shallow planting holes. Another hope was that the sandwich material after being soaked in water before use would provide sufficient moisture for the seedlings until their roots developed sufficiently to insure survival during the rainless summer months.

Figure 1.--1.0 ponderosa pine seedling encased in a sandwich, stiff fibrous material with high water absorptive capacity.

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Figure 2.--Mechanical planting hole digger designed by Roland Rotty and developed by the Arcadia Experimental Development Depot, U.S. Forest Service, Arcadia, California

The second technique was planting in holes dug mechanically. The equipment, designed by Roland Rotty, was developed by the Arcadia Experimental Development Depot of the U.S. Forest Service (fig. 2). The machine was designed to dig two concentric holes: an outer hole 36 inches in diameter and 4 to 6 inches deep and an inner hole 9 inches in diameter and about 9 inches deep. The disk blades which dig the outer hole also sever the shallow roots of adjacent competing vegetation and form a catchment basin to trap water.

The advantages desired from the machine were higher planting efficiency by increasing the number of established trees per unit cost and elimination of competition from shallow-rooted plants during the critical first year.

Specific objectives of the studies were:

(1) To compare survival and growth of ponderosa pine 1-0 seedlings planted in holes dug with the planting hoe and the mechanical planting hole digger.

(2) To compare survival and growth of seedlings planted bare-root (fig. 3) and encased in sandwiches.

(3) To determine if fertilizer is required when trees are planted in sandwiches.

(4) To determine if survival and growth of conifer seedlings can be increased with an application of fertilizer.

(5) To determine whether the mechanical planting hole digger can effectively reduce competition from brush by cutting off the lateral roots.

Figure 3.--(Left) Bare-root, 1-0 ponderosa pine seedling grown at Oakdale Nursery.

Figure 4.--(Right) 1-0 ponderosa pine seedling puddled in a slurry of forest soil.

(6) To compare survival and growth of ponderosa pine seedlings when the roots were puddled in a slurry of forest soil with roots not puddled (fig. 4).

METHODS

Central California--Ponderosa Pine.--The first series of plots was installed in the central Sierra Nevada near Groveland on the Stanislaus National Forest, April 17 and 18, 1958. At this location the study was designed to test both of the new planting techniques. Ponderosa pine 1-0 seedlings from the Oakdale Nursery were planted in three randomized blocks. Each block contained 8 rows, representing 8 different treatments, with 14 trees per row. Trees in half the rows were planted in holes dug with the mechanical digger. The other trees were planted in holes dug with a planting hoe. Trees in each of the planting hole methods were treated in one of four ways:

(1) Roots encased in the sandwich. The sandwich material was soaked overnight in water and the seedling roots were puddled in a slurry of forest soil (Holland sandy loam).

(2) Same as No. 1 except that the sandwich material was soaked in a fertilizer solution (2 ounces of 10-10-10 fertilizer per gallon of water) and the seedling roots were puddled in a fertilized slurry of forest soil (18 ounces of uramite, 38-0-0, added to 4 gallons of mud).

(3) Roots puddled in a slurry of forest soil but not encased in the sandwich material.

(4) Same as No. 3 except that the forest soil contained uramite at the same rate as above and was mixed with the fertilizer solution used to soak the sandwich material.

All sandwich-planted trees were set in the holes deep enough to place the tops of the sandwiches about an inch below the ground surface. This precaution minimized water loss which might have occurred through a wick action of the fiberboard.

In an adjacent area, 10 randomized plots were installed to compare survival and growth of ponderosa pine 1-0 seedlings treated in one of two ways:

(1) Roots puddled in a slurry of forest soil.

(2) Roots not puddled.

All trees in these 10 plots were planted in holes prepared with the mechanical digger.

Northern California--Ponderosa Pine.--A second series of plots was installed on the Bogus Burn, Klamath National Forest, on April 23, 1958. The area had been cleared of brush in 1957 by tractor piling followed by burning in the late fall. The sandwich planting technique was the only method tested in this area. Ponderosa pine 1-1 transplants from the Mt. Shasta Nursery were planted in 10 randomized blocks. Each block contained 3 rows of 15 trees each. All trees in each row were planted with a planting hoe in one of three ways:

(1) In the sandwiches with the sandwich material soaked overnight in a slurry of forest soil (Underwood clay loam).

(2) Same as No. 1 except that the sandwich material was soaked in a fertilizer solution ($1\frac{1}{2}$ ounces of 6-9-6 fertilizer per gallon of water) and the slurry contained uramite at the same rate as at Groveland.

(3) Bare-root stock without fertilizer.

Northwestern California--Douglas-fir.--A third series of plots was installed in northwestern California on the Lower Trinity Ranger District, Six Rivers National Forest, on May 8, 1958. Logging slash

had been burned and the ground was relatively free of competing vegetation. As on the Bogus Burn, only sandwich planting was tested. Douglas-fir 2-0 seedlings from the Parlin Fork Nursery were planted in four randomized blocks. Each test block consisted of 3 rows with 20 trees per row. All trees in each row were planted by one of three ways:

(1) Standard planting with the planting hoe (bare-root).

(2) Sandwich planting with sandwich material soaked for 4 hours in water and seedling roots puddled in a slurry of forest soil (Hugo clayey loam).

(3) Same as No. 2 except that the sandwich material was soaked in a fertilizer solution ($1\frac{1}{2}$ ounces of 7-9-5 fertilizer per gallon of water) and seedling roots were puddled in a fertilized slurry of forest soil (uramite added at same rate as at the other two locations).

RESULTS

Survival of the planted trees was checked on all plots several times during the growing season and at the end of the first full growing season. First-year growth was measured on the Groveland plots only.

Central California--Ponderosa Pine.--On the Groveland plots, where both new planting techniques were tested, survival for the main treatments (table 1) was higher for:

(1) Mechanical hole digger--73 percent compared to 51 percent for the planting hoe.

(2) Puddled bare-root stock--77 percent compared to 46 percent for sandwich planting.

(3) Unfertilized trees--75 percent compared to 49 percent for fertilized.

The fertilized seedlings planted in sandwiches had the lowest survival--26 percent for those planted in holes dug with the mechanical digger and 12 percent for the planting hoe method. Unfertilized trees in sandwiches had a much higher survival rate--83 percent for the mechanical digger and 64 percent for the planting hoe.

There was no difference in survival between puddled and non-puddled ponderosa pine 1-0 seedlings--both were 100 percent (table 2).

The largest seedlings at the end of the first year were those planted as puddled bare-root stock (tables 2 and 3). The puddled bare-root trees averaged a half-inch more growth than the unpuddled bare-root and 2.2 inches more than the trees in sandwiches.

The average fertilized bare-root tree was 2.5 inches taller than the average fertilized sandwich-planted tree (table 3). However, the average growth of all fertilized trees was only 1.1 inches more than the unfertilized trees at the end of the first growing season.

Northern California--Ponderosa Pine.--On the Bogus Burn, bare-root seedlings also fared better than sandwich-planted trees--83 percent survival compared to 36 percent (table 4). Most of the difference in survival rates was caused by the fertilizer treatment. Even so, the survival of unfertilized sandwich-planted trees was 20 percent lower than the bare-root.

Northwestern California--Douglas-fir.--Relatively similar results were experienced with the Douglas-fir planting on the Lower Trinity Ranger District (fig. 5) which was examined several times during the growing season. Statistical analyses of the seedling counts showed highly significant differences in survival for the three examination dates during the period June 17 to July 28; and significant differences on August 14; but differences were not significant at the final examination on October 21. The lower overall survival at this location probably was due to the poor condition of the Douglas-fir seedlings at the time of planting.

SUMMARY AND CONCLUSIONS

A mechanical planting-hole digger may offer some improvement in California over the conventional planting-hoe method, particularly where certain kinds of competing vegetation covers the planting site. Survival at Groveland, for example, was significantly higher for trees planted in holes prepared by the mechanical digger than in holes dug by hand (table 5). And on one of the plots which was covered with bearmat (Chamaebatia foliolosa Benth.) first year survival of bare-root stock was 75 percent for seedlings planted in the holes dug mechanically compared to only 36 percent for the planting hoe.

The mechanical digger offers considerable promise for planting on gentle slopes or flat areas which are free of rocks and roots. Further development and field testing is required, however, to improve the design and operation before the machine can be recommended for general field use. At Groveland, for example, the production rate was only 480 holes per 8-hour day--no more than a man can dig in the same period with a planting hoe. Furthermore, the model did not perform adequately on either steep slopes or areas with large rocks or roots.

The first-year trials of sandwich planting left much to be desired. The advantages hoped for were to correct faulty planting and to aid seedling establishment in areas of low summer rainfall. Although sandwiches may have reduced some faulty planting, they did not improve survival.

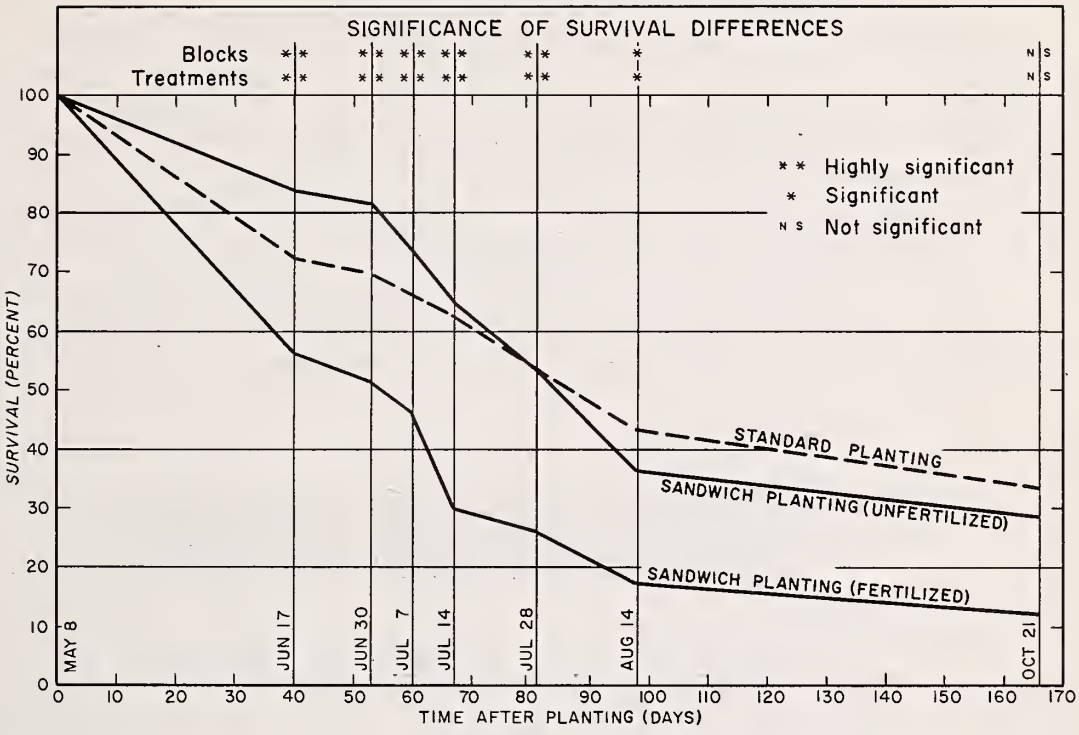

Figure 5.--Survival of 2-0 Douglas-fir seedlings planted by the sandwich technique and the standard method, Parker Unit, Six Rivers National Forest, 1958.

Planting Douglas-fir in sandwiches without fertilizer at first seemed beneficial in northwestern California, but any early-season benefit vanished by July 28. After summer began, the soil near the ground surface dried, and the roots probably did not grow out of the sandwiches deeper into the soil where moisture was still available. As with ponderosa pine, the final results did not show any advantages for sandwiches over bare-root planting.

The greatest mortality occurred among seedlings in sandwiches to which fertilizer had been added. This was true for both species planted. Survival was 3 to 4 times higher for unfertilized sandwich planting than for fertilized.

Since heavy seedling mortality did not occur with unfertilized sandwiches or in the fertilized bare-root treatments, we believe the total concentration of fertilizer was too high in the fertilized sandwiches. Some mortality may be attributed to not soaking the fibrous material long enough to obtain complete saturation. We noted that the

innermost layers of sandwich material sometimes were still dry after soaking 4 hours. The sandwich material soaked overnight was not examined. Before conducting further trials with this material, the soaking time to obtain complete saturation should be determined.

Comparison of average heights at Groveland shows a slight advantage for the fertilized trees (table 3). The greatest stimulation of growth caused by fertilizer occurred in the bare-root seedlings; and least in the sandwich-planted trees. At best, these differences amounted to only about a half-inch during the first growing season. The trees will be re-examined at a later date to evaluate the effect of fertilizer on growth.

Tests of the mechanical planting hole digger and fertilizer treatments should be replicated further to evaluate the equipment and materials on different planting areas over time.

Table 1.--First-year survival of 1-0 ponderosa pine seedlings by planting methods for sandwich and bare-root planting--Groveland, 1958

Planting methods	Sandwich			Bare-root (puddled)			All
	Fertilized	Not fertilized	Average	Fertilized	Not fertilized	Average	
	Percent						
Mechanical digger	26	83	54	90	93	92	73
Planting hoe	12	64	38	67	60	63	51
Average	19	74	46	77	76	77	62

Table 2.--First-year survival and height of bare-root 1-0 ponderosa pine seedlings by puddling treatment--Groveland, 1958

Root treatment	Survival		Average height (inches)
	Number	Percent	
Puddled	100	100	7.8
Not puddled	90	100	7.3

Table 3.--First-year height of 1-0 ponderosa pine seedlings by planting methods for sandwich and bare-root planting--Groveland, 1958

Planting methods	Sandwich			Bare-root (puddled)			Planting method average
	Fertilized	Not fertilized	Average	Fertilized	Not fertilized	Ave.	
	Average height (inches)						
Mechanical digger holes	5.9	5.8	5.9	8.8	8.1	8.4	7.5
Planting hoe	6.6	6.4	6.4	8.2	7.7	8.0	7.4
Average	6.1	6.1	6.1	8.6	7.9	8.3	7.4

Table 4.--First-year survival of 1-1 ponderosa pine transplants for sandwich and bare-root planting--Bogus, 1958

Type of planting	Survival	
	Number	Percent
Sandwich:	108	36
Fertilized	28	19
Not fertilized	80	53
Bare-root (puddled)	125	83
All	233	52

Table 5.--Analysis of variance of first-year survival data of experiment to test method of digging planting holes (H), comparison of bare-root and sandwich (S), and fertilizer treatment (F),--Groveland, 1958

Source of variation	d.f.	Sum of square	Mean square	F
Total	23	616.33		
Blocks	2	163.08	81.54	11.67**
Planting hole (H)	1	60.16	60.16	8.61*
Sandwich (S)	1	112.66	112.66	16.12**
Fertilizer (F)	1	80.66	80.66	11.54**
H x S	1	4.18	4.18	0.60 NS
H x F	1	1.51	1.51	0.22 NS
S x F	1	96.01	96.01	13.74**
H x S x F	1	0.15	0.15	0.02 NS
Error	14	97.92	6.99	

* Significant
** Highly significant
NS Not significant